CLAIMS

1. An adsorption heat pump which comprises an adsorbate, an adsorption/desorption part having an adsorbent for adsorbate adsorption/desorption, a vaporization part for adsorbate vaporization which has been connected to the adsorption/desorption part, and a condensation part for adsorbate condensation which has been connected to the adsorption/desorption part, wherein the adsorbent, when examined at 25°C, gives a water vapor adsorption isotherm which, in the relative vapor pressure range of from 0.05 to 0.30, has a relative vapor pressure region in which a change in relative vapor pressure of 0.15 results in a change in water adsorption amount of 0.18 g/g or larger.

2. The adsorption heat pump as claimed in claim 1, wherein the adsorbent comprises a zeolite having a framework density in the range of from 10.0 T/1,000 $Å^3$ to 16.0 T/1,000 $Å^3$.

3. The adsorption heat pump as claimed in claim 2, wherein the adsorbent is an adsorbent having a pore diameter of from 3 Å to 10 Å and a heat of adsorption of from 40 kJ/mol to 65 kJ/mol.

4. The adsorption heat pump as claimed in any one of claims 1 to 3, characterized in that the adsorbent is a zeolite containing at least aluminum, phosphorus, and a heteroatom in the framework structure.

5. The adsorption heat pump as claimed in claim 4, wherein the zeolite is one in which the proportions of atoms present therein are represented by the following expressions (1), (2), and (3):

$$0.001 \leqq x \leqq 0.3 \quad (1)$$

(wherein x represents the molar proportion of the heteroatom in the framework structure to the sum of aluminum, phosphorus, and the heteroatom in the framework structure);

$$0.3 \leqq y \leqq 0.6 \quad (2)$$

(wherein y represents the molar proportion of aluminum in the framework structure to the sum of aluminum, phosphorus, and the heteroatom in the framework structure);

$$0.3 \leqq z \leqq 0.6 \quad (3)$$

(wherein z represents the molar proportion of phosphorus in the framework structure to the sum of aluminum, phosphorus, and the heteroatom in the framework structure).

6. The adsorption heat pump as claimed in claim 4 or 5, wherein the heteroatom is silicon.

7. The adsorption heat pump as claimed in claim 4 or 5, wherein the heteroatom is silicon and the zeolite gives a ^{29}Si-MAS-NMR spectrum in which the integrated intensity area for the signals at from -108 ppm to -123 ppm is not more than 10% based on the integrated intensity area for the signals at from -70 ppm to -123 ppm.

8. The adsorption heat pump as claimed in claim 7, wherein the zeolite gives a ^{29}Si-MAS-NMR spectrum in which the integrated intensity area for the signals at from -70 ppm to -92 ppm is not less than 25% based on the integrated intensity area for the signals at from -70 ppm to -123 ppm.

9. The adsorption heat pump as claimed in any one of claims 2 to 8, wherein the zeolite is one having the structure represented by CHA in terms of the code defined by International Zeolite Association (IZA).

10. The adsorption heat pump as claimed in any one of claims 2 to 9, wherein the adsorbent has a zeolite content of 60% by weight or higher based on the whole adsorbent.

11. The adsorption heat pump as claimed in any one of claims 1 to 10, wherein the adsorbent, when examined at 25°C, gives a water vapor adsorption isotherm in which the

adsorption amount at a relative vapor pressure of 0.05 is 0.15 g/g or less.

12. An adsorption heat pump which comprises (a) an adsorbate, (b) an adsorption/desorption part having an adsorbent for adsorbate adsorption/desorption, (c) a vaporization part for adsorbate vaporization which has been connected to the adsorption/desorption part, and (d) a condensation part for adsorbate condensation which has been connected to the adsorption/desorption part,

characterized in that

(1) the adsorbent comprises a zeolite containing aluminum and phosphorus in the framework structure, and

(2) the adsorbent is a water vapor adsorbent having a region in which the adsorption amount difference as determined with the following equation is 0.15 g/g or larger in the range in which the relative vapor pressure $\phi 2b$ during adsorption operation in the adsorption/desorption part is from 0.115 to 0.18 and the relative vapor pressure $\phi 1b$ during desorption operation in the adsorption/desorption part is from 0.1 to 0.14:

Adsorption amount difference = Q2 - Q1

wherein

Q1 = adsorption amount at $\phi 1b$ as determined from a water vapor desorption isotherm obtained at a temperature (T3) used for desorption

operation in the adsorption/desorption part

Q2 = adsorption amount at ϕ2b as determined from a water vapor adsorption isotherm obtained at a temperature (T4) used for adsorption operation in the adsorption/desorption part,

provided that

ϕ1b (relative vapor pressure during desorption operation in the adsorption/desorption part) = [equilibrium water vapor pressure at the temperature of coolant (T2) cooling the condenser]/[equilibrium water vapor pressure at the temperature of heat medium (T1) heating the adsorption/desorption part]

ϕ2b (relative vapor pressure during adsorption operation in the adsorption/desorption part) = [equilibrium vapor pressure at the temperature of cold (T0) generated in the vaporization part]/[equilibrium vapor pressure at the temperature of coolant (T2) cooling the adsorption/desorption part]

(wherein T0=5 to 10°C, T1=T3=90°C, and T2=T4=40 to 45°C).

13. The adsorption heat pump as claimed in claim

12, wherein T0 is 10°C and T2 is 40°C.

14. The adsorption heat pump as claimed in claim 12, wherein T0 is 5°C and T2 is 40°C.

15. The adsorption heat pump as claimed in claim 12, wherein T0 is 10°C and T2 is 45°C.

16. The adsorption heat pump as claimed in any one of claims 12 to 15, characterized in that the adsorbent has a region in which the adsorption amount difference is 0.15 g/g or larger in the range in which $\phi 1b$ and $\phi 2b$ are from 0.115 to 0.18 and $\phi 1b$ is equal to or higher than $\phi 2b$.

17. The adsorption heat pump as claimed in any one of claims 12 to 16, characterized in that the zeolite comprises a heteroatom in the framework structure.

18. The adsorption heat pump as claimed in claim 17, characterized in that the proportions of aluminum, phosphorus, and the heteroatom present in the zeolite are as follows:

$$0.001 \leqq x \leqq 0.3$$

(x = molar proportion of the heteroatom in the framework structure to the sum of aluminum, phosphorus, and the heteroatom in the framework structure);

$$0.3 \leqq y \leqq 0.6$$

(y = molar proportion of aluminum in the framework structure to the sum of aluminum, phosphorus, and the heteroatom in the framework structure);

$$0.3 \leqq z \leqq 0.6$$

(z = molar proportion of phosphorus in the framework structure to the sum of aluminum, phosphorus, and the heteroatom in the framework structure).

19. The adsorption heat pump as claimed in any one of claims 12 to 18, characterized in that the zeolite is a zeolite having a framework density of from 10.0 T/1,000 $Å^3$ to 16.0 T/1,000 $Å^3$.

20. An adsorption heat pump which comprises an adsorbate, an adsorption/desorption part having an adsorbent for adsorbate adsorption/desorption, a vaporization part for adsorbate vaporization which has been connected to the adsorption/desorption part, and a condensation part for adsorbate condensation which has been connected to the adsorption/desorption part, characterized in that the adsorbent comprises a zeolite containing aluminum, phosphorus, and a heteroatom in the framework structure.

21. An adsorption heat pump which comprises (a) an

adsorbate, (b) an adsorption/desorption part having an adsorbent for adsorbate adsorption/desorption, (c) a vaporization part for adsorbate vaporization which has been connected to the adsorption/desorption part, and (d) a condensation part for adsorbate condensation which has been connected to the adsorption/desorption part, characterized in that the adsorbent comprises a zeolite containing aluminum, phosphorus, and silicon in the framework structure, and that the zeolite gives a ^{29}Si-NMR spectrum in which the integrated intensity area for the signals at from -108 ppm to -123 ppm is not more than 10% based on the integrated intensity area for the signals at from -70 ppm to -123 ppm.

22. Use of an adsorbent as an adsorbent for an adsorption heat pump, the adsorbent being one which, when examined at 25°C, gives a water vapor adsorption isotherm which, in the relative vapor pressure range of from 0.05 to 0.30, has a relative vapor pressure region in which a change in relative vapor pressure of 0.15 results in a change in water adsorption amount of 0.18 g/g or larger.

23. The use of an adsorbent as an adsorbent for an adsorption heat pump as claimed in claim 22, wherein the adsorbent comprises a zeolite having a framework density in the range of from 10.0 T/1,000 Å^3 to 16.0 T/1,000 Å^3.

24. The use as claimed in claim 23, wherein the adsorbent is an adsorbent having a pore diameter of from 3 Å to 10 Å and a heat of adsorption of from 40 kJ/mol to 65 kJ/mol.

25. The use as claimed in any one of claims 22 to 24, characterized in that the adsorbent is a zeolite containing aluminum, phosphorus, and a heteroatom in the framework structure.

26. The use as claimed in claim 25, wherein the zeolite is one in which the proportions of atoms present therein are represented by the following expressions (1), (2), and (3):

$$0.001 \leqq x \leqq 0.3 \quad (1)$$

(wherein x represents the molar proportion of the heteroatom in the framework structure to the sum of aluminum, phosphorus, and the heteroatom in the framework structure);

$$0.3 \leqq y \leqq 0.6 \quad (2)$$

(wherein y represents the molar proportion of aluminum in the framework structure to the sum of aluminum, phosphorus, and the heteroatom in the framework structure);

$$0.3 \leqq z \leqq 0.6 \quad (3)$$

(wherein z represents the molar proportion of phosphorus in

the framework structure to the sum of aluminum, phosphorus, and the heteroatom in the framework structure).

27. The use as claimed in claim 25 or 26, wherein the heteroatom is silicon.

28. The use as claimed in claim 25 or 26, wherein the heteroatom is silicon and the zeolite gives a ^{29}Si-MAS-NMR spectrum in which the integrated intensity area for the signals at from -108 ppm to -123 ppm is not more than 10% based on the integrated intensity area for the signals at from -70 ppm to -123 ppm.

29. The use as claimed in claim 28, wherein the zeolite gives a ^{29}Si-MAS-NMR spectrum in which the integrated intensity area for the signals at from -70 ppm to -92 ppm is not less than 25% based on the integrated intensity area for the signals at from -70 ppm to -123 ppm.

30. The use as claimed in any one of claims 23 to 29, wherein the zeolite is one having the structure represented by CHA in terms of the code defined by International Zeolite Association (IZA).

31. The use as claimed in any one of claims 23 to 30, wherein the adsorbent has a zeolite content of 60% by

weight or higher based on the whole adsorbent.

32. The use as claimed in any one of claims 22 to 31, wherein the adsorbent, when examined at 25°C, gives a water vapor adsorption isotherm in which the adsorption amount at a relative vapor pressure of 0.05 is 0.15 g/g or less.

33. Use of a water vapor adsorbent as an adsorbent for an adsorption heat pump, the adsorbent (1) comprising a zeolite containing aluminum and phosphorus in the framework structure and (2) having a region in which the adsorption amount difference as determined with the following equation is 0.15 g/g or larger in the range in which the relative vapor pressure $\phi2$ during adsorption operation in an adsorption/desorption part is from 0.115 to 0.18 and the relative vapor pressure $\phi1$ during desorption operation in the adsorption/desorption part is from 0.1 to 0.14:

Adsorption amount difference = Q2 - Q1

wherein

Q1 = adsorption amount at $\phi1$ as determined from a water vapor desorption isotherm obtained at a temperature (T3) used for desorption operation in the adsorption/desorption part

Q2 = adsorption amount at $\phi2$ as determined from a water vapor desorption isotherm obtained

at a temperature (T4) used for desorption operation in the adsorption/desorption part,

provided that

$\phi 1$ (relative vapor pressure during desorption operaton in the adsorption/desorption part) = [equilibrium water vapor pressure at the temperature of coolant (T2) cooling the condenser]/[equilibrium water vapor pressure at the temperature of heat medium (T1) heating the adsorption/desorption part]

$\phi 2$ (relative vapor pressure during adsorption operation in the adsorption/desorption part) = [equilibrium vapor pressure at the temperature of cold (T0) generated in a vaporization part]/[equilibrium vapor pressure at the temperature of coolant (T2) cooling the adsorption/desorption part]

(wherein T0=5 to 10°C, T1=T3=90°C, and T2=T4=40 to 45°C).

34. The use as claimed in claim 33, wherein T0 is 10°C and T2 is 40°C.

35. The use as claimed in claim 33, wherein T0 is 5°C and T2 is 40°C.

36. The use as claimed in claim 33, wherein T0 is 10°C and T2 is 45°C.

37. The adsorption heat pump as claimed in any one of claims 33 to 36, characterized in that the adsorbent has a region in which the adsorption amount difference is 0.15 g/g or larger in the range in which $\phi 1$ and $\phi 2$ are from 0.115 to 0.18 and $\phi 1$ is equal to or higher than $\phi 2$.

38. The use as claimed in any one of claims 33 to 37, characterized in that the zeolite contains a heteroatom in the framework structure.

39. The use as claimed in claim 38, characterized in that the proportions of aluminum, phosphorus, and the heteroatom present in the zeolite are as follows:

$$0.001 \leqq x \leqq 0.3$$

(x = molar proportion of the heteroatom in the framework structure to the sum of aluminum, phosphorus, and the heteroatom in the framework structure);

$$0.3 \leqq y \leqq 0.6$$

(y = molar proportion of aluminum in the framework structure to the sum of aluminum, phosphorus, and the heteroatom in the framework structure);

$$0.3 \leqq z \leqq 0.6$$

(z = molar proportion of phosphorus in the framework structure to the sum of aluminum, phosphorus, and the heteroatom in the framework structure).

40. The use as claimed in claim 38 or 39, characterized in that the zeolite is a zeolite having a framework density of from 10.0 T/1,000 Å^3 to 16.0 T/1,000 Å^3.

41. An air conditioning system for vehicles which employs the adsorption heat pump as claimed in any one of claims 1 to 21.